Measuring Accurate Turbulence using Commercial Lidars

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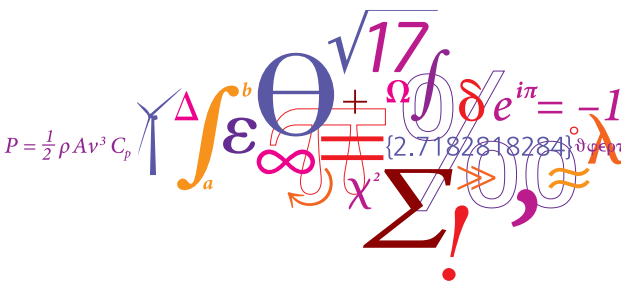
A. Sathe

DTU Wind Energy



DTU Wind Energy
Department of Wind Energy

Outline

- Motivation

Outline

- Motivation
- Measurements – Part 1

Outline

- Motivation
- Measurements – Part 1
- Measurements – Part 2

Outline

- Motivation
- Measurements – Part 1
- Measurements – Part 2
- Conclusions

Key Learning Objectives

- How can the commercial lidars be used as stand-alone instruments for estimating turbulence statistics?
- Could we somehow achieve a slope close to one, e.g. $TI_{\text{lidar}} \approx TI_{\text{reference}}$?
- What extra measurements, if any, are required for that purpose?

Commercial Lidar Scanning Configurations

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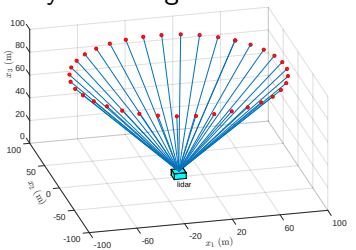
Conically Scanning



Commercial Lidar Scanning Configurations

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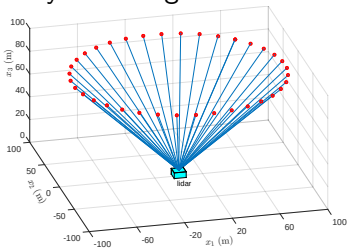
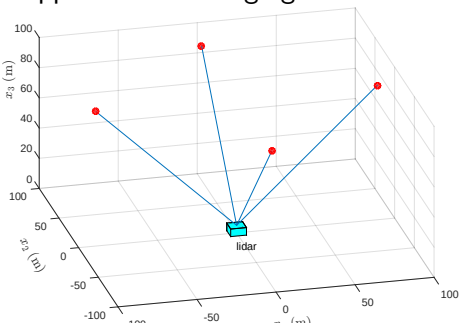


Doppler Beam Swinging



Mean wind vs Turbulence measurements – VAD Method

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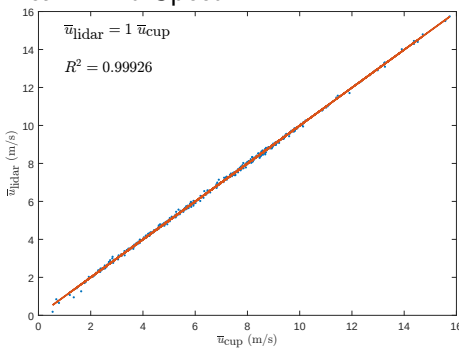
Mean Wind Speed



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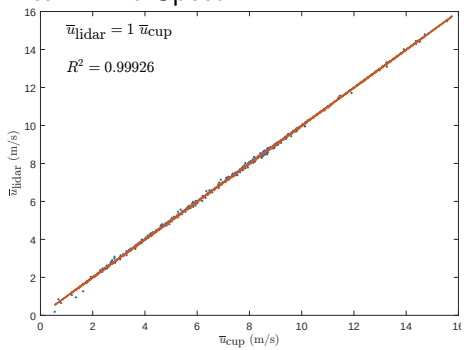
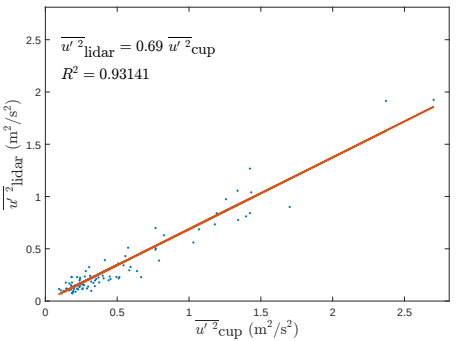


Turbulence



Comparison of the mean wind speed

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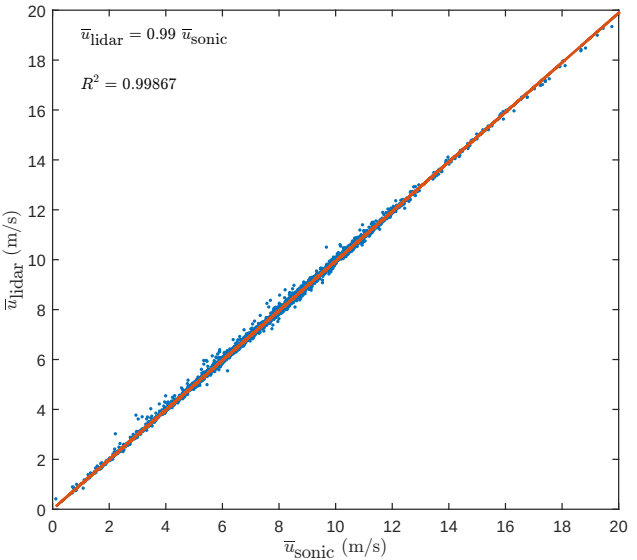

Improvement in Turbulence Intensity Estimates – Very Unstable

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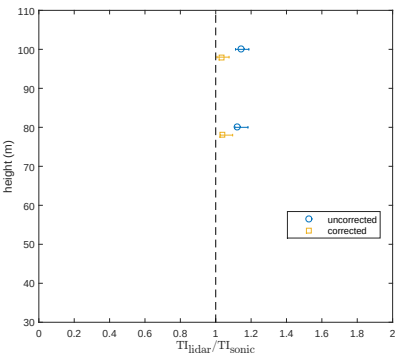
Ratio of TI_{lidar} to TI_{sonic}



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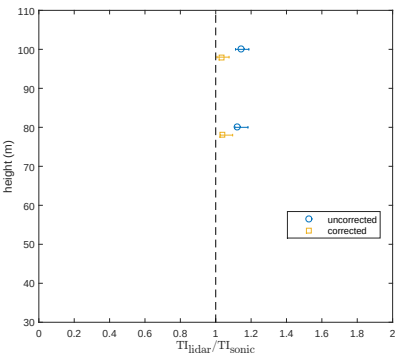
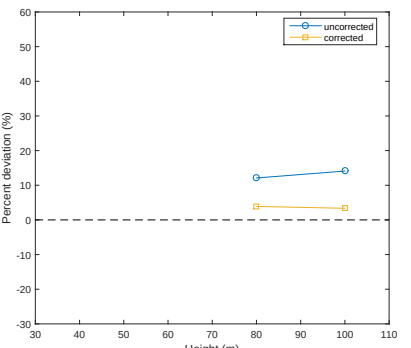


$(TI_{lidar} - TI_{sonic})/TI_{sonic} \times 100$



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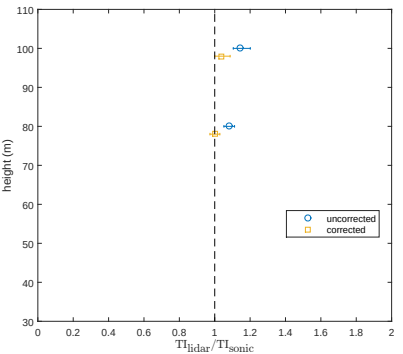

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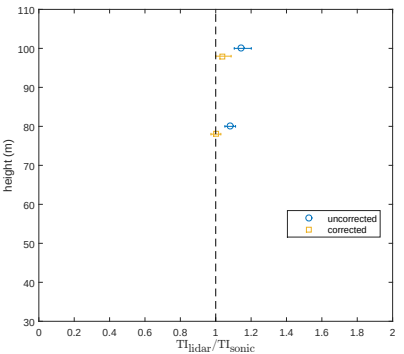

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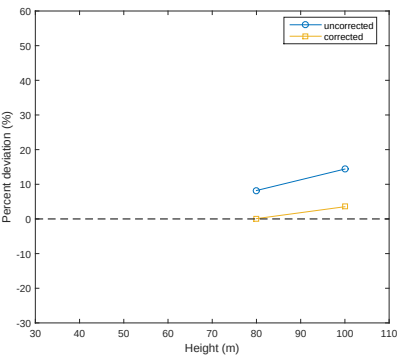

Improvement in Turbulence Intensity Estimates – Near-Neutral Unstable

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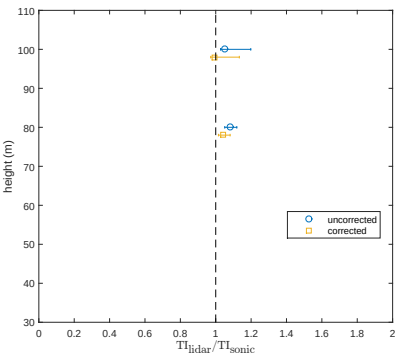

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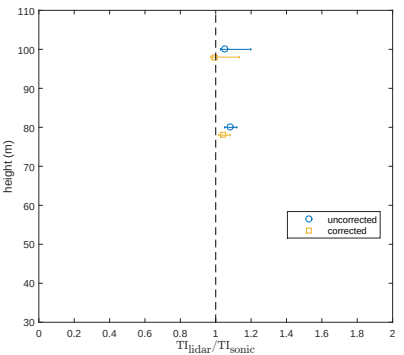

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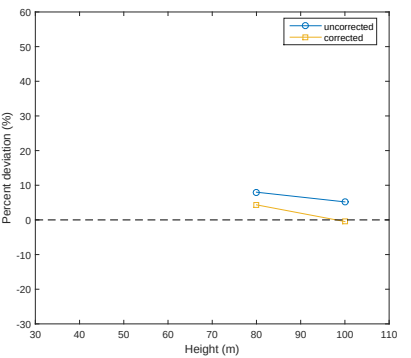

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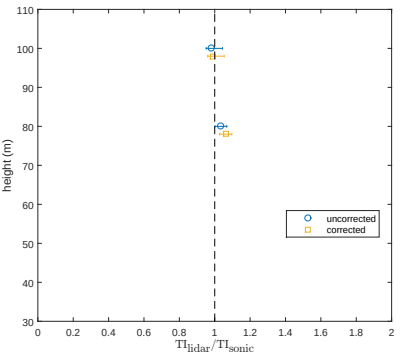

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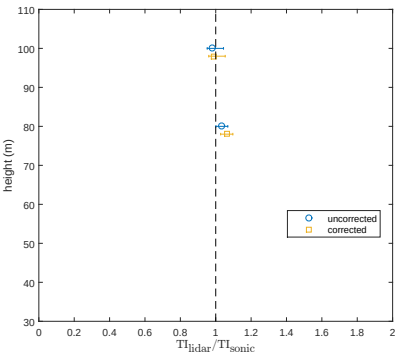

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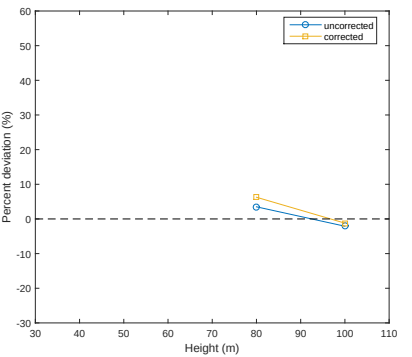

Improvement in Turbulence Intensity Estimates – Near-Neutral Stable

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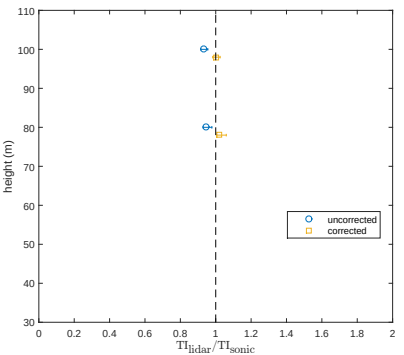

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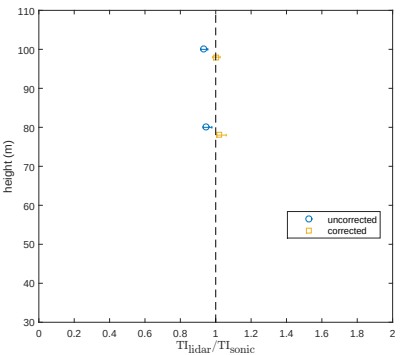

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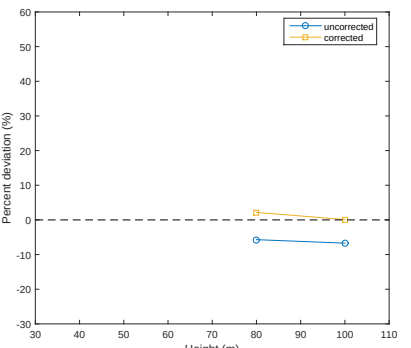

Improvement in Turbulence Intensity Estimates – Stable

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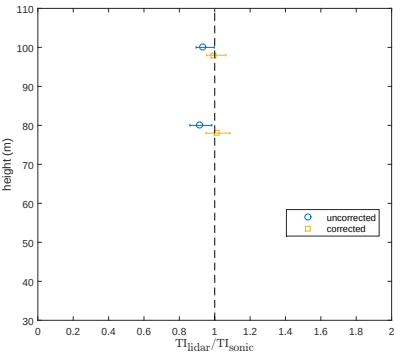

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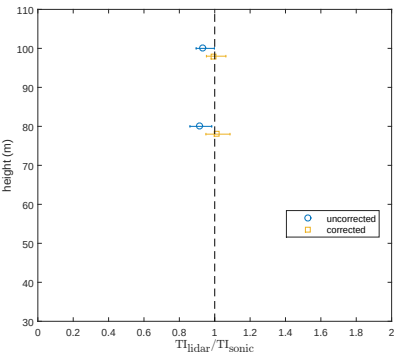

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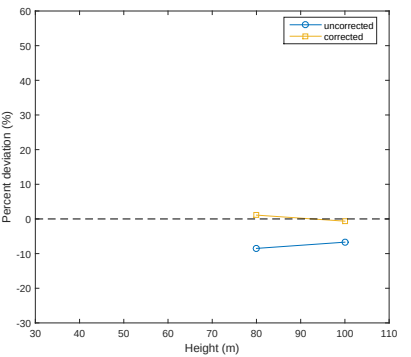
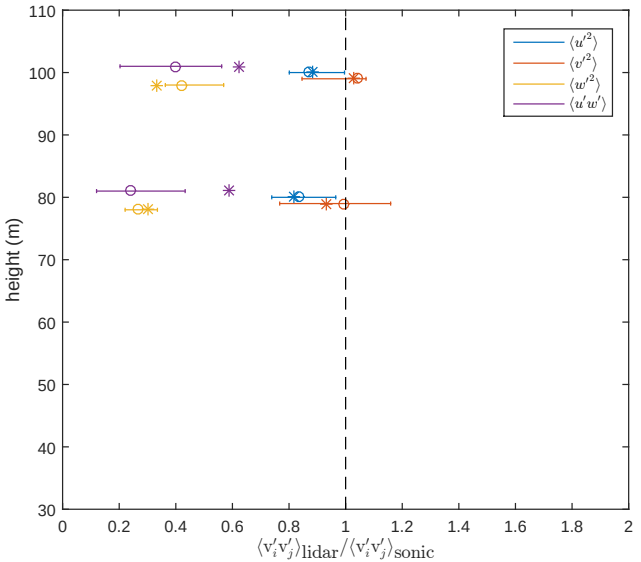


Comparison of the modelled and measured systematic errors



Summary of Part 1

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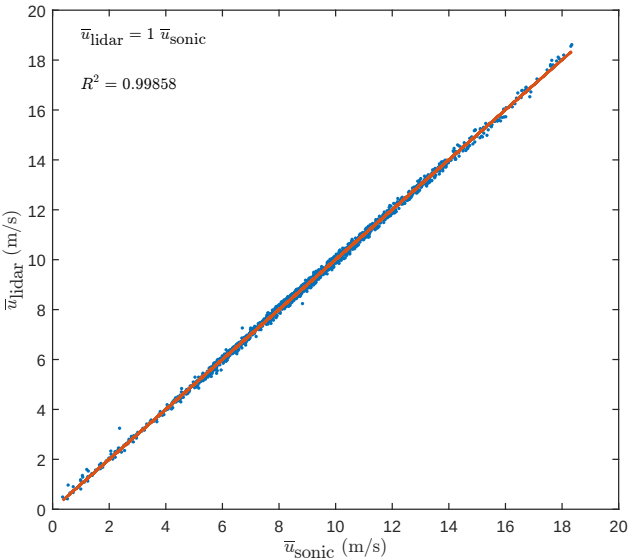
Amongst all the cases the approximate percentage of cases when there is an improvement in TI measurements of WindCube using the SLEMT model at

- 80 m – 65 %
- 100 m – 81 %

Comparison of the mean wind speed



Improvement in Turbulence Intensity Estimates – Very Unstable

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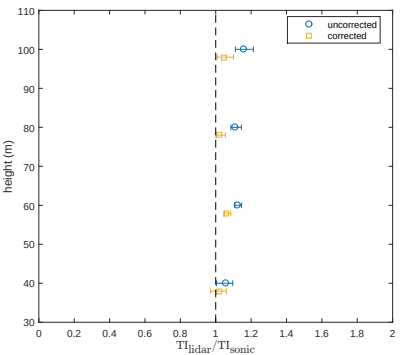

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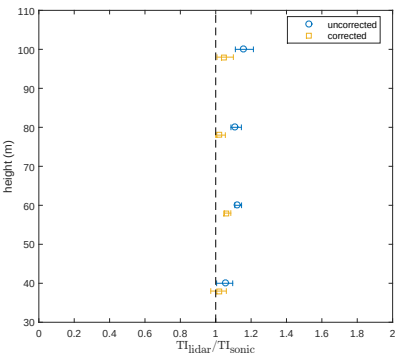

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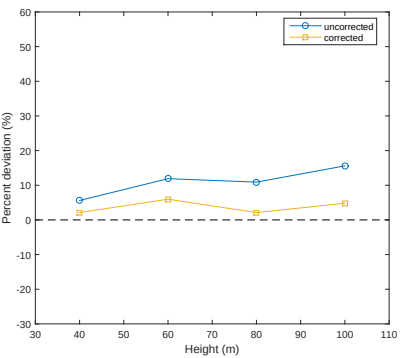

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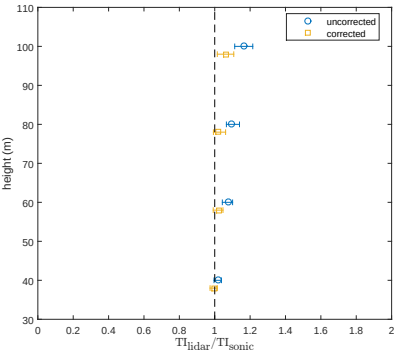

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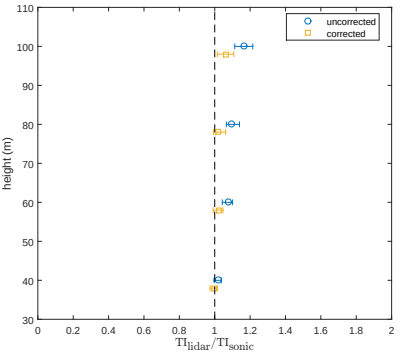

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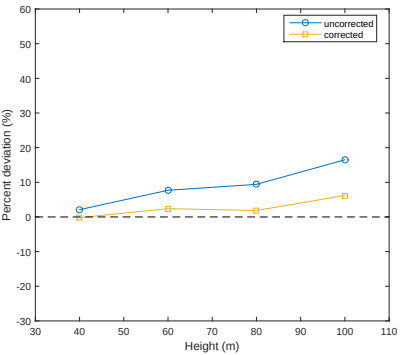

Improvement in Turbulence Intensity Estimates – Near-Neutral Unstable

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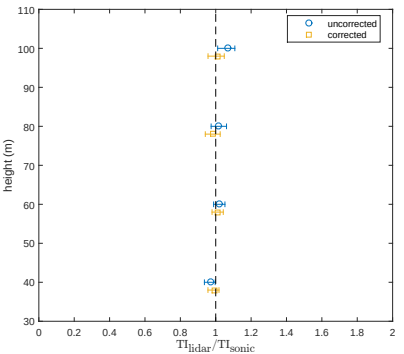

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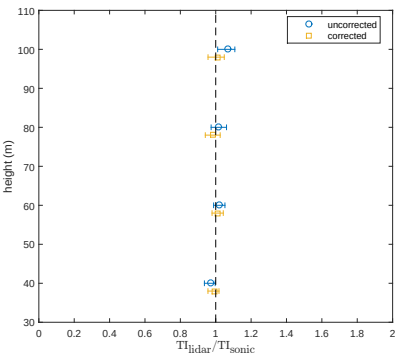

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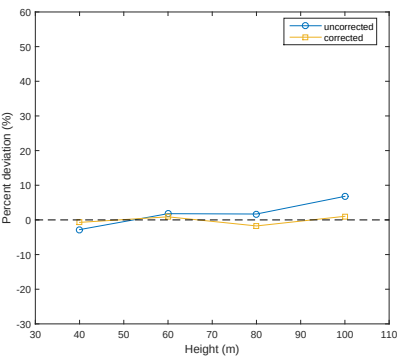

Improvement in Turbulence Intensity Estimates – Neutral

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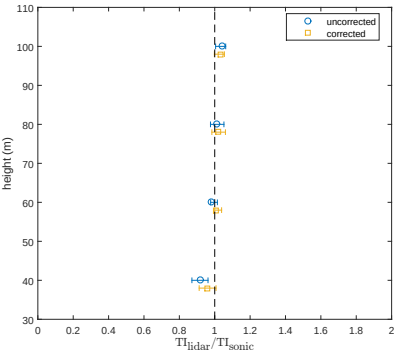

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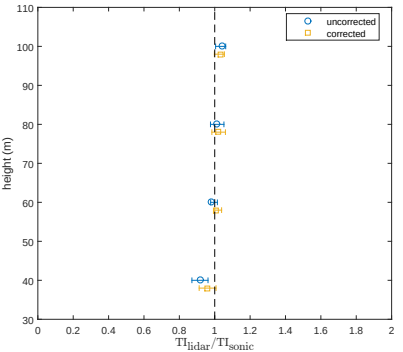

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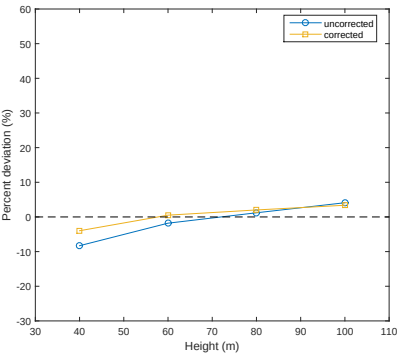

Improvement in Turbulence Intensity Estimates – Near-Neutral Stable

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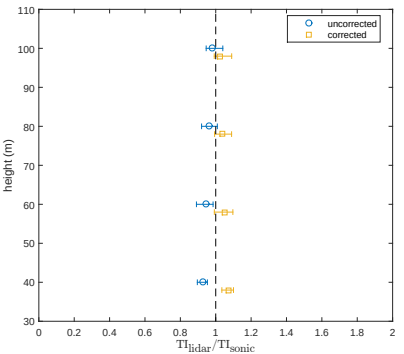

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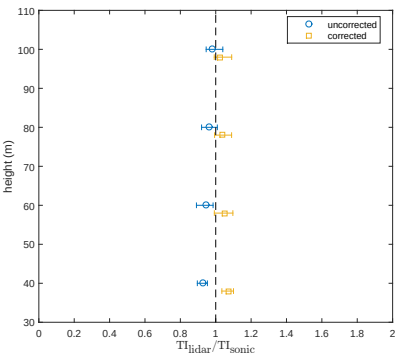

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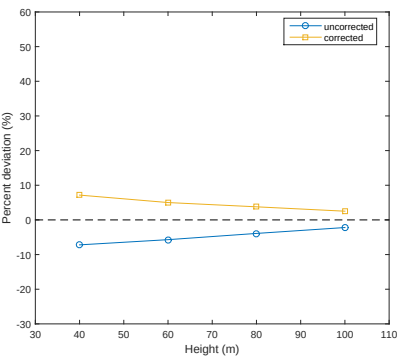

Improvement in Turbulence Intensity Estimates – Stable

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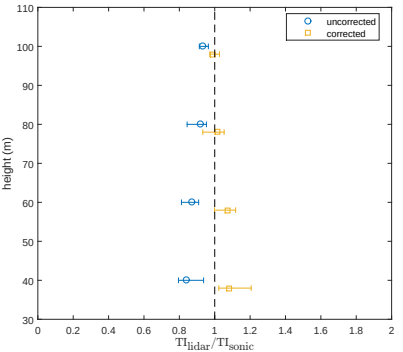

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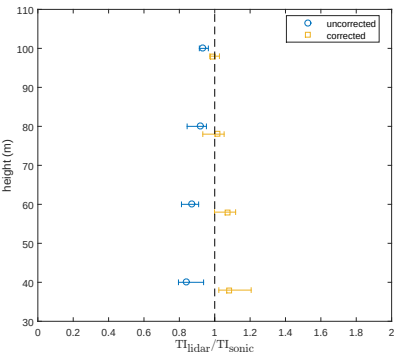

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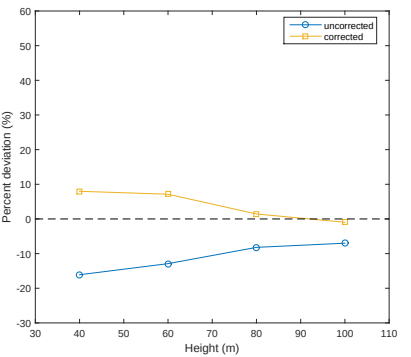
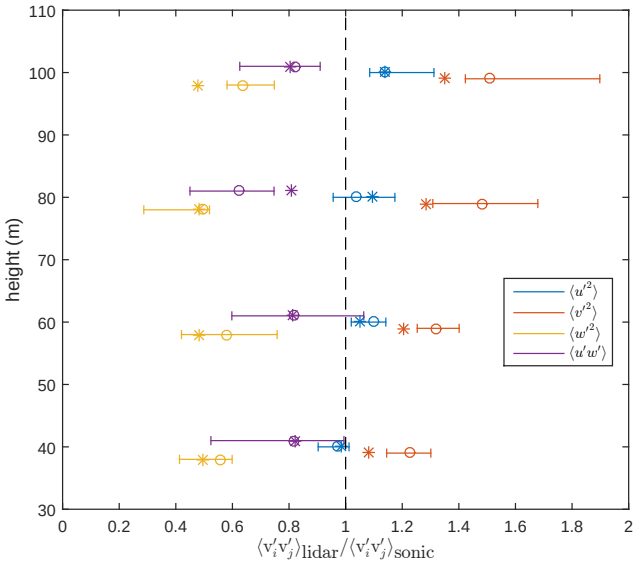


Comparison of the modelled and measured systematic errors



Summary of Part 2

Summary of Part 2

Amongst all the cases the approximate percentage of cases when there is an improvement in TI measurements of WindCube using the SLEMT model at

- 40 m – 72 %
- 60 m – 52 %
- 80 m – 53 %
- 100 m – 70 %

Conclusions and Next Steps

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Next Steps

- Obtain data from one or two offshore locations where the WindCube is co-located with the mast
- Apply the estimated correction factors to the WindCube data from these locations

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Atmospheric Stability! The most desired solution would be to have a 10 m met mast with a sonic anemometer. However there are also other ways to estimate stability, e.g. using Richardson numbers.

Thank you!

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